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Piezoresponse force microscopy of ferroelectric thin films

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RIJKSUNIVERSITEIT GRONINGEN

**PIEZORESPONSE FORCE MICROSCOPY OF
FERROELECTRIC THIN FILMS**

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Piezoresponse force microscopy of ferroelectric thin films

Alessio Morelli

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Front cover: PRphase three dimensional image of a $2 \times 2 \mu\text{m}^2$ area of a PZT sample after poling a 5×5 array over a $1 \times 1 \mu\text{m}^2$ area: the peaks represent downward polarization (poled areas), while in the rest of the area the polarization is upward (virgin state).

Rear cover: representation of perovskite-type crystal unit cells showing downward and upward polarization configuration.

The image in the front cover and all the AFM images in this thesis were processed via WSxM by Nanotec (www.nanotec.es).

The work described in this thesis was carried out within the framework of the Zernike Institute for Advanced Materials, University of Groningen under the project number 367844.

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Abbreviations

FeRAM	Ferroelectric Random Access Memory
DRAM	Dielectric Random Access Memory
PZT	$\text{PbZr}_x\text{Ti}_{1-x}\text{O}_3$
PTO	PbTiO_3
SRO	SrRuO_3
STO	SrTiO_3
SPM	Scanning Probe Microscope
AFM	Atomic Force Microscope
R_{ROC}	Apex radius of AFM tip
TM-AFM	Tapping Mode AFM
SSPM	Scanning Surface Potential Microscopy
C-AFM	Conductive AFM
PFM	Piezoresponse Force Microscopy
PRphase	Piezoresponse phase
PRamplitude	Piezoresponse amplitude
LiA	Lock-in amplifier
PSD	Phase Sensitive Detector
TEM	Transmission Electron Microscopy
HRTEM	High Resolution TEM
PLD	Pulsed Laser Deposition